

REMARKS

Claims 74-75, 77 and 79 have been amended. No new matter has been added. Claims 74-80 and 82-83 are currently pending in this application. Applicant reserves the right to pursue the original and other claims in this and other applications.

Applicant respectfully requests that the Examiner acknowledge acceptance of the replacement drawing filed on February 23, 2006.

Claims 74 and 75 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Okada (U.S. Patent No. 6,424,036) ("Okada") in view of Tao et al. (U.S. Patent No. 5,891,802) ("Tao"). The rejection is respectfully traversed and reconsideration is respectfully requested.

Claim 74 recites a copper bond pad for a semiconductor device including a "dielectric layer," a "barrier layer," a "copper layer having titanium implanted within and near only an upper surface of [the] copper layer, [the] copper layer being primarily copper and having a thickness of about 500 Angstroms to about 20,000 Angstroms," and an "insulating layer over [the] copper layer." The "implanted titanium acts to reduce formation of copper oxide on said copper layer."

Thus, the claimed invention relates to a multi-layered copper bond pad on which the formation of copper oxide is inhibited. This is accomplished by implanting titanium into the copper layer, which suppresses the copper oxide growth by controlling the concentration of vacancies available to the copper ion transport.

Okada relates to a method of forming, with a reduced number of steps, semiconductor devices including barrier metal films between an insulating film and the copper layer and between copper layers. (Abstract, FIG. 5). As stated in the Office Action, Okada does not discuss a copper layer having implanted titanium. The Office

Action relies on Tao for this feature. Tao relates to a metallization stack structure that provides higher electromigration resistance and relatively low resistivity as compared to those formed of aluminum. (Abstract). This is accomplished by sandwiching a pure copper layer between top and bottom thin doped copper layers. (Abstract).

Applicant respectfully submits that the combination of Okada and Tao does not disclose, teach or suggest all of the limitations of claim 74. Specifically, the cited combination does not disclose, teach or suggest a “copper layer having titanium implanted within and near only an upper surface of said copper layer, said copper layer being primarily copper and having a thickness of about 500 Angstroms to about 20,000 Angstroms . . . wherein said implanted titanium acts to reduce formation of copper oxide on said copper layer.”

Assuming Okada and Tao are combinable, which Applicant does not concede, the resulting structure would include a copper layer doped with titanium on both sides of the copper layer. The doped titanium in Tao is for reducing the formation of voids induced by electrical current when it runs through the copper layer. The claimed invention, on the other hand, requires the implanted titanium to be “within and near only an upper surface of said copper layer.” (emphasis added). Additionally, the implanted titanium of the claimed invention “acts to reduce formation of copper oxide on said copper layer.” These claim limitations are not disclosed in or suggested by the combination of Okada and Tao.

Accordingly, claim 74 is allowable over the cited combination. Claim 75 depends from claim 74 and is allowable along with claim 74. Applicant respectfully requests that the rejection be withdrawn and the claims allowed.

Claims 76-78 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Okada in view of Tao and further in view of Hsu et al. (U.S. Patent No. 5,661,082) ("Hsu"). The rejection is respectfully traversed and reconsideration is respectfully requested.

Claims 76-78 depend from claim 74 and are allowable over the combination of Okada in view of Tao for the reasons set forth above for claim 74. Hsu is relied upon as teaching a passivation layer, a via formed in the passivation layer, and possible materials for forming the dielectric layer. (Office Action, page 3). Applicant respectfully submits, however, that Hsu does not remedy the deficiencies of the Okada and Tao combination. That is, Hsu also fails to teach or suggest a "copper layer having titanium implanted within and near only an upper surface of said copper layer, said copper layer being primarily copper and having a thickness of about 500 Angstroms to about 20,000 Angstroms . . . wherein said implanted titanium acts to reduce formation of copper oxide on said copper layer."

Accordingly, claims 76-78 are allowable for at least the reasons set forth above for claim 74. Applicant respectfully requests that the rejection be withdrawn and the claims allowed.

Claims 79, 80 and 82-83 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Jang et al. (U.S. Patent No. 6,423,625) ("Jang") in view of Harada et al. (U.S. Patent No. 5,565,378) ("Harada") in view of Mahulikar et al. (U.S. Patent No. 5,320,689) ("Mahulikar"). The rejection is respectfully traversed and reconsideration is respectfully requested.

Claim 79 recites an interconnect structure for a semiconductor die including a "conductive bond pad containing a copper layer" where the "copper layer contain[s] a

copper oxide layer thereon” and a “titanium-aluminum-copper-nitrogen layer formed as part of [the] copper layer and from a portion of at least an upper surface of [the] copper layer.”

Jang relates to adding an aluminum layer (alloyed with up to 1% copper) (i.e., an AlCu layer) over a copper bond pad. The purpose of the AlCu layer is to allow for successful bonding of gold wire to the copper bond pad. (col. 1, lines 53-61).

Harada relates to adding small amounts of one of many possible materials, including copper and titanium, to an aluminum alloy film in order to enhance the resistance to electromigration. (col. 6, lines 54-61).

Mahulikar relates to a composite copper alloy having a copper alloy core and a modified surface layer containing a nitride or carbide film. (Abstract) This surface layer acts as a barrier on the surface of an iron or nickel-based alloy, thereby providing improved tribological (i.e., friction and wear) and mechanical properties.

The cited combination does not disclose, teach or suggest all of the limitations of claim 79. Specifically, the references, even when combined, do not disclose, teach or suggest a “titanium-aluminum-copper-nitrogen layer formed as part of [the] copper layer and from a portion of at least an upper surface of [the] copper layer.” The alloyed layers described in the references are all placed over base layers, whereas in the claimed invention, the alloyed layer is formed from and as part of the copper layer. Accordingly, the limitations of claim 79 are not disclosed, taught or suggested by the cited combination.

Additionally, Applicant respectfully submits that Jang, Harada and Mahulikar are not properly combinable. There would have been no motivation to combine the references for the purpose of teaching or suggesting a titanium-aluminum-

copper-nitrogen layer absent the impermissible use of hindsight using the claims of the present application as a roadmap. The mere fact that references can be combined or modified is not sufficient to establish *prima facie* obviousness, the prior art must also suggest the desirability of the combination, which is not present here. M.P.E.P. § 2143.01 (citing In re Mills, 916 F.2d 680, 16 U.S.P.Q.2d 1430 (Fed. Cir. 1990)).

The Office Action states that the motivation to combine these references is that they “all involve the improvement of a copper film by adding elements to the copper film.” (Office action at page 6). Applicant respectfully disagrees. In fact, two of the references, Jang and Harada, actually relate to the improvement of an aluminum film by adding elements to the aluminum. The current application discusses that using a copper layer to form the bond pad is itself an improvement over using an aluminum layer, therefore, the references that teach improving aluminum teach away from the claimed invention.

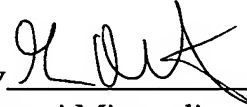
Only Mahulikar relates to an improvement of copper. Mahulikar adds nitrogen to copper result in improved tribological and mechanical properties of an iron or nickel-based alloy. This does not provide any motivation to combine this reference with any bonding pad references to reduce oxidation of copper. Accordingly, Applicant respectfully submits that one skilled in the art would not have been motivated to combine the references in the manner suggested by the Office.

Accordingly, claim 79 is allowable over the cited combination. Claims 80 and 82-83 depend from claim 79 and are allowable along with claim 79. Applicant respectfully requests that the rejection be withdrawn and the claims allowed.

In view of the above amendment, Applicant believes the pending application is in condition for allowance.

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Respectfully submitted,

By 

Gianni Minutoli

Registration No.: 41,198

Jennifer M. McCue

Registration No.: 55,440

DICKSTEIN SHAPIRO LLP

1825 Eye Street, NW

Washington, DC 20006-5403

(202) 420-2200

Attorneys for Applicant